

IMPROVED PUMPBackground of the Invention

This invention relates to pumps, and in particular, though not exclusively, to a pump for use in the oil/gas and/or chemical industries. A pump of the present invention is particularly suitable for use in a method of "artificial lift" in an oil/gas well.

In many oil wells the oil does not have enough pressure to flow all the way up the tubing to the surface. The produced water and oil has to be lifted up the tubing to the surface by one of several methods, normally called artificial lift. Even with a flowing oil well, as more fluids are removed from the subsurface reservoir, the pressure on the remaining oil decreases until it no longer flows up the tubing to the surface.

A common artificial lift apparatus is the sucker-rod pump system. The sucker-rod pump or rod-pumping system uses a downhole rod pump, a surface pumping unit, and a sucker-rod string that runs down the well to connect them. The sucker-rod pump has a standing valve and travelling valve. The travelling valve reciprocates up and down while the standing valve remains stationary.

The sucker-rod pump system suffers from a number of problems. Fluid pound is a problem caused when the produced liquid is pumped faster than it is flowing into the well. Gas enters the pump and the pump can be damaged. Gas lock is an extreme case of fluid pound. Gas

accumulates in the pump and prevents the pump from working.

An artificial lift method used on wells that produce large volumes of liquid is gas lift. In a gas lift well, a compressed inert gas called lift gas (usually natural gas that was produced from the well) is injected into the annulus in the well between the casing and tubing. Gas lift valves - pressure valves that open and close - are spaced along the tubing string. They allow the gas to flow into the tubing, where it dissolves in the liquid and also forms bubbles. This lightens the liquid and, along with the expanding bubbles, forces the produced liquid up the tubing string to the surface where the gas can be recycled. The advantages of gas lift is that there is very little surface equipment and few moving parts. Gas lift is a very inexpensive technique when many wells are serviced by only one central compressor facility. However, it is effective only in relatively shallow wells. Offshore oil wells and crooked or deviated wells that need artificial lift are usually completed with gas lift. Gas lift is either continuous or intermittent (periodically on and off) for wells with low production.

Artificial lift may also be provided by means of a submersible electrical pump. A submersible electrical pump normally uses an electric motor that drives a centrifugal pump with a series of rotating blades on a shaft located on the bottom of the tubing. An armoured electrical cable runs up the well, strapped to the tubing string. Electricity is supplied by a transformer on the surface.

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The electric motor has a variable speed that can be adjusted for lifting different volumes of liquids. Submersible electrical pumps are used for lifting large volumes of liquid and for crooked and deviated wells. A gas separator is often used on the bottom of the pump to prevent gas from forming in the pump and decreasing the pump's efficiency. Prior art electrical pumps are therefore coupled to a turbine or the like and provide axial flow of fluid.

A hydraulic pump may also be used to provide artificial lift. A known hydraulic pump is identical to a sucker-rod pump except it is driven by hydraulic pressure from a fluid pumped down the well. It uses two reciprocating pumps. One pump on the surface injects a high pressure power oil (usually crude oil from a storage tank) down a tubing string in the well. A reciprocating hydraulic motor on the bottom of the tubing is driven by the power oil. It is coupled to a pump, similar to a sucker-rod pump, and located below the fluid level in the well. The motor drives the pump, which lifts both the spent power oil and the produced fluid from the well up another tubing string. The power fluid causes the upstroke and the release of pressure causes the downstroke. It is called a parallel-free pump. In another variation, (casing-free pump), the power fluid is pumped down a tubing string and the produced liquid is pumped up the casing-tubing annulus. The stroke in a hydraulic pump is very similar to a sucker-rod pump stroke except it is shorter.

Hydraulic pumps can be either fixed (screwed onto the tubing string) or free (pumped up and down the well). They can also be either open (with downhole mixing of power and produced fluids) or closed (with no mixing). Most are free and open.

Known pumps used in artificial lift methods suffer from a number of problems/disadvantages - e.g. low efficiency (hydraulic efficiency).

It is an object of at least one aspect of the present invention to obviate or mitigate one or more of the aforementioned problems/disadvantages in the prior art.

It is a further object of at least one embodiment of the present invention to provide a pump which provides a positive displacement of a predetermined volume of well production fluid for each operative cycle of the pump - in contra-distinction to pumps of the prior art which provide axial flow of well production fluid.

Summary of the Invention

According to a first aspect of the present invention there is provided a pump providing a chamber having a volume, an inlet to the chamber, an outlet from the chamber, and means for varying the volume of the chamber.

The pump may be adapted to be used downhole - e.g. in an oil/gas well.

The means for varying the volume of the chamber may be controlled by relative rotation of first and second bodies of the pump.

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In a first embodiment the second body may be provided within the first body and may be substantially concentric therewith.

5 In a second embodiment the second body may be provided within the first body and may be substantially eccentric therewith.

The chamber may be provided within the second body, and preferably longitudinally within the second body.

10 The first and second bodies may each be of an elongate form.

The second body may comprise a rotor.

The first body may comprise a stator.

15 The means for varying the volume of the chamber may include at least one piston supported by the second body and biased by means towards the first body.

A first end of the/each piston may communicate with the chamber while a second end of the/each piston may be urged by biasing means into contact with an inner surface of the stator.

20 Relative rotation of the first and second bodies may cause movement of the piston(s) thereby varying the volume of the chamber.

25 In the first embodiment the first body may have a substantially elliptical (or oval) internal bore. Further the second body may provide a substantially cylindrical or optionally elliptical outer surface.

Alternatively, the first body may have a substantially cylindrical internal bore and the second body may provide

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a substantially elliptical outer surface.

Further the means for varying the volume of the chamber may include at least one piston supported by the first body and biased by means towards the second body.

5 In the second embodiment the first body may have a substantially cylindrical internal bore. Further the second body may provide a substantially cylindrical outer surface.

10 The inlet may include a first one-way valve and perhaps one or more back-up valves.

The outlet may include a second one-way valve and perhaps one or more back-up valves.

15 There may be provided at least one pair of pistons supported by, and preferably provided substantially within, the second body and radially opposing one another relative thereto.

There may be provided a plurality of pair of pistons, each pair being longitudinally spaced from an adjacent pair along the second body.

20 The/each piston may include a rotatable member free to rotate at least along a longitudinal axis with respect to the rotor.

The/each piston may also include a piston member.

25 The piston member may include a concave portion capable of receiving at least a portion of the rotatable member.

In one embodiment each rotatable member may be in the form of a sphere, e.g. a ball bearing.

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In an alternative embodiment each rotatable member may be in the form of a cylinder, e.g. a rod (roller).

The means for varying the volume of the chamber may be driven by any suitable drive means - e.g. hydraulic, pneumatic, or electric.

The drive means may include a drive shaft for rotating the rotor, in use.

Preferably the rotor may be provided with at least one seal (or bushing) for sealing engagement with the stator.

Preferably the/each seal is/are made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper alloys and stainless steel.

Preferably the piston member(s) is/are made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper alloys and stainless steel. The piston(s) may be hollow, spherical, cylindrical, cuboid or polygonal.

Preferably the rotatable member(s) is/are made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper, alloys and stainless steel. The rotatable member(s) may be hollow, spherical or cylindrical.

Preferably the/each biasing means, e.g. spring(s), is/are made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper alloys and stainless steel.

Preferably the rotor is provided with at least two

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piston apertures which are disposed substantially opposite one another, each of the piston apertures being provided with a respective piston.

Preferably each piston may have a slot, hole or gap to
5 allow fluid to flow through the piston from the chamber,
i.e. rotor channel, which fluid flow may assist in
lubricating contacting surfaces of the piston(s) and the
stator and the piston(s) and the rotor.

10 In a preferred embodiment the pump may
comprise/include 24 pistons and respective biasing means,
wherein each piston and biasing means may work
individually in series, or in parallel with one another.
This feature is particularly beneficial in seeking to allow
continuous flow of drive fluid through the pump, thereby,
15 for example, obviating or mitigating hydraulic hose
vibration.

The rotor may be provided with a plurality of pistons
arranged in pairs, each aperture of each pair being
substantially opposite to the other.

20 In a preferred embodiment one biasing means may be
used for each piston of a pair by traversing the chamber/
rotor channel, but not cutting off fluid flow through the
chamber.

25 In a preferred embodiment one or more one valves may
be used for the inlet of the pump, and one or more one way
valves may be used for the outlet of the pump, allowing
fluid flow to travel through the chamber.

According to a second aspect of the present invention,

there is provided a plurality of pumps according to the first aspect so arranged as to be operating connected with one another.

The pumps may operate in phase with one another and
5 may not be separated by a one-way valve(s).

Alternatively, the pumps may be arranged so that, in use the pumps operate out of phase with one another. Thus two pumps with two chambers each may be connected 90 degrees out of phase with one another. Alternatively, two
10 pumps each with four chambers may be connected 45 degrees out of phase. Arrangements such as these help to ensure a smooth output and inhibit drive motor stalling.

At least one first vent hole may be manufactured at a desired position through the stator, allowing any pressure differential across the stator to be equalised, and held to
15 the pressure external to the pump.

The rotor may be provided within at least one bearing pack which may include at least one radial bearing and at least one thrust bearing. The bearing pack may include at
20 least one seal at a fluid upstream end and at least one seal at a fluid downstream section end of the bearing pack(s).

At least one second vent hole may be manufactured at a desired position through a bearing housing, allowing any
25 pressure differential across the bearing pack(s) to be equalised, and held to the pressure external to the pump.

The rotor may be connected to a drive by means of a spline, hex, polygon or other similar coupling.

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According to a third aspect of the present invention there is provided a well completion including at least one pump, the at least one pump providing a chamber having a volume, an inlet to the chamber, and an outlet from the chamber, and means for varying the volume of the chamber.

According to a fourth aspect of the present invention there is provided a method of artificial lift within an oil/gas well comprising the steps of:

lowering a pump to a desired position within a borehole of a well, the pump providing a chamber having a volume, an inlet to the chamber, an outlet from the chamber and means for varying the volume of the chamber;

driving the pump by varying the volume of the chamber thereby pumping well fluids downstream through the pump and a tubing of the well.

Herein the term upstream is intended to mean closer to the well source, and downstream is intended to mean nearer to surface.

According to a fifth aspect of the present invention there is provided a pump including an inlet, a filter means associated with the inlet, and means for cleaning the filter means.

The filter means may comprise a substantially cylindrical body and may carry an end plate.

The filter means may be formed from a sheet form mesh material.

The means for cleaning the filter means may be driven

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by means by which the pump is driven.

The pump may provide a chamber having a volume, an inlet communicating with the chamber, and further an outlet from the chamber, and means for varying the volume of the chamber.

The means for varying the volume of the chamber may be controlled by relative rotation of first and second bodies of the pump.

The first and second bodies may comprise a stator and a rotor, respectively.

In one embodiment, the filter means may be rigidly attached to the rotor so as to rotate therewith.

The means for cleaning may comprise at least one blade, knife or scraper, to be known hereinbelow as the blade(s), rigidly attached to the stator.

The blade(s) may have a serrated edge or surface which, when coming into contact with the filter means, in use, may allow any debris or contamination build up on the filter means to be removed.

Preferably the filter means is/are made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper alloys and stainless steel.

Preferably the blade(s) is/are made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper alloys and stainless steel.

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Brief description of the Drawings

Embodiments of the present invention will now be described by way of example only, with reference to the accompanying drawings, which are:

5 Fig 1 a detailed sectional side view of a pump according to a first embodiment of the present invention;

Fig 2 a detailed sectional view along line A-A of Fig 1 in a first position;

10 Fig 3 a detailed sectional view along line A-A of Fig 1 in a second position;

Fig 4 a schematic sectional side view of a well completion including a pump according to Fig 1; and

15 Fig 5 a detailed sectional view from the top of a second embodiment of the present invention.

Detailed Description of the Drawings

Referring initially to Figs 1 to 3 there is shown a pump, generally designated 5, according to a first
20 embodiment of the present invention. The pump 5 provides a chamber 10, having a volume V, an inlet 15 to the chamber 10 an outlet 20 from the chamber 10, and means for varying the volume V of the chamber 10, which will be described in greater detail hereafter.

25 The pump 5 includes filter means 25 associated with the inlet 15 and means for cleaning the filter means, which will also be described in greater detail hereinafter. The

filter means 25 are rigidly attached to the rotor 35.

The pump 5 of this embodiment is adapted to be used downhole - e.g. in an oil/gas well.

5 The means for varying the volume V of the chamber 10 is controlled by relative rotation of first and second elongate bodies - comprising a stator 30 and a rotor 35 respectively - of the pump. In this embodiment the rotor 35 is provided within the stator 30, substantially concentric therewith. The chamber 10 is provided longitudinally within the rotor 35. The means for varying the volume V of the chamber 10 includes a plurality of pistons 40 supported by the rotor 35 and biased towards an inner surface of the stator 30.

10 A first end of each piston 40 communicates with the chamber 10 while a second end of each piston 40 is urged by biasing means such as a coiled spring 45 into contact with the inner surface of the stator 30.

15 As can be seen from Figs 2 and 3, the stator 30 has a substantially elliptical or oval internal bore. Further the rotor 35 provides a substantially cylindrical outer surface.

20 Relative rotation of the stator 30 and rotor 35 thus causes movement of the pistons 40 thereby varying the volume V of the chamber 10.

25 The inlet 15 includes a first one-way valve 50 while, the outlet 20 includes a second one-way valve 55.

As can be seen from Figs 1 to 3, there are provided a plurality of pairs of pistons 40 supported by and provided

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5 Each piston 40 includes a rotatable member 60 free to
rotate at least longitudinally with respect to a piston
member 65. The piston member 65 includes a concave portion
69 capable of receiving at least a portion of the rotatable
member 60. In this embodiment each rotatable member 60
0 is in the form of a sphere, e.g. a ball bearing.

The means for varying the volume V of the chamber 10 are driven by any suitable drive means - e.g. hydraulic, pneumatic, or electric. The drive means includes a drive shaft 70 for rotating the rotor 35 in use.

Further the piston members 65 are made from a material selected from the group consisting of plastics, polyethylethylketone, metal, copper alloys and stainless steel.

Yet further the rotatable members 60 are made from a material selected from the group consisting of plastics

materials, polyethylethylketone, metal, copper alloys and stainless steel.

Further also springs 45 are made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper alloys and stainless steel.

The rotor 35 is provided with pairs of piston apertures 80, each of the piston apertures 80 being provided with a respective piston 40.

As can be seen from Figure 1 each piston member 65 has a slot, hole or gap to allow fluid to bleed through the piston member from the chamber 10, i.e. channel, which fluid flow assists in lubricating contacting surfaces body of each piston 40 and the stator 30.

In this embodiment the pump 10 may comprise/include 24 pistons 40 and 12 coiled springs 45. This feature is particularly beneficial in seeking to allow continuous flow of drive fluid through the pump 5, thereby, for example, obviating or mitigating hydraulic hose vibration.

The rotor 35 is provided with a plurality of pistons 40 arranged in pairs, each aperture 80 of each pair being substantially opposite to the other.

Further, one coiled spring 45 is used for each piston 40 of a pair by traversing the chamber 10 - but not cutting off fluid flow through the chamber 10.

In a modified embodiment more than one one way valve may be provided at inlet 15 of the pump 10, and more than one one way valve may be provided at the outlet 20 of the

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pump 10 allowing fluid flow to travel through the chamber 10.

It will be appreciated that a plurality of pumps 5 according to the invention may be so arranged as to be operated connected with one another.

For example, the pumps may be arranged so that in use, the pumps operate out of phase with one another. Thus two pumps with two chambers each may be connected 90 degrees out of phase with one another. Alternatively, two pumps each with four chambers may be connected 45 degrees out of phase. Arrangements such as these to help to ensure a smooth output and inhibit motor stalling.

Referring to Fig. 1 at least one first vent hole 85 is provided through the stator 30, allowing any pressure differential across the stator 30 to be equalised, and held to the pressure external to the pump 10.

The rotor 35 is provided within a bearing pack 90 held within a bearing housing 95, the pack 90 including at least one radial bearing and at least one thrust bearing 90, and at least one seal 100 upstream and at least one seal 105 downstream of the bearing pack 90.

The bearing pack 90 includes at least one second vent hole 110 provided through the bearing housing 95, allowing any pressure differential across the radial bearing(s) and thrust bearing(s) to be equalised, and held to the pressure external to the pump 10.

The rotor 35 is connected to a drive means including drive shaft 70 by a coupling 115, e.g. a spline, hex or

other similar coupling provided with a drive housing 116.

Referring to Fig 1 the means for cleaning the filter means 25 are driven by means by which the pump 5 is driven. The filter means 25 comprise a substantially cylindrical body made of a sheet mesh, and carries an end plate 160. The cleaning means comprise a pair of elongate blades 120 rigidly attached to the stator 30. The blades 120 may have a serrated edge or surface which, when coming into contact with the filter means 25, in use, allow any debris or contamination build up on the filter means 25 to be removed.

The filter means 25 is made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper alloys and stainless steel.

The blades 120 are made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper alloys and stainless steel.

In use, the rotor 35 is rotated via the drive means including driveshaft 70. Well fluid is caused to pass through the filter 25 while the rotor 35 rotates. The blades 120 which may be stationary relative to the filter means 25 constantly clean the filter means 25. The filtered fluid then passes through the inlet 15 and first one way valve 50.

The fluid then enters the chamber 10 (aided by a possible positive differential surrounding/external

pressure) when the pistons 40, in their maximum extended positions, are shown in a non-power position, as shown in Figure 3. As the rotor 35 is driven through 90 degrees, as in Figure 2, the pistons 40 are forced inwards due to the internal elliptical shape of the stator 30 thus compressing the fluid within the chamber 10. The resulting pressure change within the chamber 10 forces the first one way valve 50 shut and the second one way valve 55 open allowing fluid to flow through the chamber 10 within the bearing housing 95 and to surface. This process is cyclical and occurs twice per revolution.

It is envisaged that the embodiment of the invention described above, which may represent a 3 1/8" diameter of pump 5, may supply fluid at an approximate working pressure of 5000 PSI and a flowrate of approximately 23.16 litres per minute which is equal to 210 US barrels per day.

For the disclosed 24 piston embodiment the flow rate Q may be calculated from:

$$Q = \frac{\text{NUMBER OF PISTONS} \times \text{CYCLES PER REVOLUTION OF ROTOR} \times \left[\frac{\pi}{4} \times \left[\text{DIAMETER OF CHANNEL} \right]^2 \right] \times \text{STROKE DISTANCE BALL BEARINGS MOVE}}{1}$$

Referring to Fig 4 there is shown a well completion, generally designated 125, comprising a borehole 130 having a casing 135. Within the casing 135 there is provided a production tubing 140, and between the casing 135 and tubing 140 one or more packers 145.

When it is desired to provide artificial lift a pump 5 is lowered down within tubing 140 to a desired position on coiled tubing 150 or the like.

The pump 5 may be driven via power line 155 which may be a hydraulic or electric line suitable for driving the drive means to which the rotor 35 is connected. In use, therefore, well produce is delivered to the surface via the coiled tubing 150.

Referring now to Fig. 5 there is shown a pump, generally designated 5', according to a second embodiment of the present invention. Like parts of the pump 5' are identified by the same numerals as for the pump 5 of the first embodiment, but suffixed "'".

In the pump 5' the first elongate body comprises a stator 30' and the second elongate body comprises a rotor 35'. As be seen from Fig. 5 the rotor 35' is provided within the stator 30' but longitudinally eccentric relative thereto. Further, the stator 30' has a substantially cylindrical inner bore, while the rotor 35' also has a substantially cylindrical outer surface.

The stator 30' has a central axis "S'", while the rotor has a central axis "R'".

By this arrangement relative rotations of the rotor 35' and stator 30' causes movement of the piston(s) 40 thereby causing the volume V' of the chamber 10' to be varied.

It will be appreciated that the embodiments of the invention hereinbefore described are given by way of

Particular advantages of the disclosed embodiment will be appreciated. For example the disclosed pump is completely mechanical and is a metal based device.

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